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PATENT APPLICATION

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HYODO, Manabu et al.

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For: METHOD AND APPARATUS FOR AUTOMATIC WHITE BALANCE ADJUSTMENT BASED UPON LIGHT SOURCE TYPE

DECLARATION ACCOMPANYING ENGLISH TRANSLATION

Honorable Commissioner of Patents
Washington, D.C. 20231

Sir:

Hiroyuki Iida, of No.302, 1-10, Higashi 4-Chome, Kunitachi-Shi, Tokyo 186-0002 Japan hereby declare that:

I am familiar with both the Japanese and English languages.

I have prepared the English translation attached hereto of the certified copy of Japanese Patent Application No. 11-025523, filed on February 2, 1999.

I believe that the attached English translation is a true, faithful and exact translation of the corresponding Japanese language application.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: November 1, 2004

Hiroyuki IIDA
Translator, Japanese patent attorney

PATENT OFFICE JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Application Number: 11-025523

Applicant: Fuji Photo Film Co., Ltd.

Date: October 8, 1999

Commissioner, Patent Office: TAKAHIKO KONDO

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【List of Enclosures】

【Enclosure】 Specification 1

【Enclosure】 Drawing 1

【Enclosure】 Abstract of the Disclosure 1

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【Document Name】 Specification

【TITLE OF THE INVENTION】 AUTOMATIC WHITE BALANCE ADJUSTMENT METHOD

【SCOPE OF THE PATENT CLAIMS】

【Claim 1】 An automatic white balance adjustment method, comprising the steps of:

detecting a luminance level of a subject;

dividing an image plane, on which the subject is imaged, into a plurality of areas and acquiring color information of each of the areas;

setting one detection frame indicating a color distribution range corresponding at least to a type of a light source and finding a number of the areas belonging to the detection frame in accordance with the acquired color information of each of the areas;

determining a type of a light source is according to the luminance level of the detected subject and the number of the areas belonging to the detection frame; and

adjusting a white balance suitable for the type of the determined light source.

【Claim 2】 The automatic white balance adjustment method as defined in claim 1, wherein:

the color information comprises a ratio R/G and B/G between R, G, B signals in each of the areas; and

the detection frame is a frame which is specified by a range of the ratio R/G and a range of the ratio

B/G.

【Claim 3】 The automatic white balance adjustment method as defined in claim 1, wherein:

the detection frame comprises a shade detection frame indicating a color distribution range of an outdoor shade; and

the number of the area belonging to the shade detection frame is restricted to the number of the area of which luminance is not more than a predetected luminance.

【Claim 4】 The automatic white adjustment method as defined in claim 3, wherein:

the detection frame comprises a blue sky detection frame indicating a color distribution range of a blue sky; and

the number of the area belonging to the blue sky detection frame is restricted to the number of the area of which luminance is not less than a predetected luminance.

【Claim 5】 The automatic white balance adjustment method as defined in claim 4,wherein:

calculating an evaluation value expressing how much the subject appears in outdoor shade according to the following equation:

the evaluation value expressing how much the subject appears in outdoor shade = F(outdoor) * F(shade) * F(blue sky),

where F(outdoor) : a value of a membership function of which variable is the luminance level and expresses how much the subject appears outdoors,

F(shade) : a value of a membership function of which variable is the number of the areas wherein luminance is not more than a predetected luminance and which belong to the shade detection frame, and expresses how much the subject appears in outdoor shade

F(blue sky) : a value of a membership function of which variable is the number of the areas wherein luminance is not less than a predetected luminance and which belong to the blue sky detection frame;

determining that the type of the light source is outdoor shade when the evaluation value is not less than a predetected value; and

determining that the type of the light source is daylight when the evaluation value is not more than the predetected value.

【Claim 6】 The automatic white balance adjustment method, further comprising the step of:

determining whether or not to flash an electronic flash according to the luminance level of the detected subject,

wherein the automatic white balance adjustment method is applied only when it is determined not to flash the electronic flash, and the automatic white balance adjustment method which is suitable for the

electronic flash is performed when it is detected to flash the electronic flash.

【Claim 7】 The automatic white balance adjustment method as defined in claim 1, wherein:

the type of the light source comprises a shade, a fluorescent lamp and an electric bulb; and

the detection frames comprises a shade detection frame, a fluorescent lamp detection frame, an electric bulb detection frame, a blue sky detection frame and a skin pigmentation detection frame.

【Claim 8】 The automatic white balance adjustment method as defined in claim 7, wherein:

calculating an evaluation value expressing how much the subject appears in outdoor shade, an evaluation value expressing how much the light source appears the fluorescent lamp, and an evaluation value expressing how much the light source appears the electric bulb according to the following equations:

the evaluation value expressing how much the subject appears in outdoor shade = F(outdoor) * F(shade) * F(blue sky);

the evaluation value expressing how much the light source appears the fluorescent lamp = F_1(indoor) * F(fluorescent lamp); and

the evaluation value expressing how much the light source appears the electric bulb = F_2(indoor) * F(electric bulb) * F(skin pigmentation),

where F(outdoor) : a value of a membership function of which variable is the luminance level and expresses how much the subject appears outdoors,

F_1(indoor) : a value of a membership function of which variable is the luminance level and expresses how much the light source is the fluorescent lamp

F_2(indoor) : a value of a membership function of which variable is the luminance level and expresses how much the light source is the electric bulb

F(shade) : a value of a membership function of which variable is the number of the areas wherein luminance is not more than a predetected luminance and which belong to the shade detection frame, and expresses how much the subject appears as if in outdoor shade

F(blue sky) : a value of a membership function of which variable is the number of the areas wherein luminance is not less than a predetected luminance and which belong to the blue sky detection frame;

F(fluorescent lamp) : a value of a membership function of which variable is the numbers of the areas belonging to the fluorescent lamp detection frame and expresses how much the light source appears the fluorescent lamp

F(electric bulb) : a value of a membership function of which variable is the numbers of the areas belonging to the electric bulb detection frame

and expresses how much the light source appears the electric bulb

F(skin pigmentation) : a value of a membership function of which variable is the numbers of the areas belonging to the skin pigmentation detection frame and expresses how much the subject appears to include the skin pigmentation;

determining, when a maximum one of the evaluation values is not less than a predetected value, that the type of the light source is as the light source corresponding to the maximum one of the evaluation values; and

determining that the type of the light source is daylight when it is not more than the predetected value.

【Detailed Description of the Invention】

【0001】

【Field of the Invention】

The present invention relates generally to an automatic white balance adjustment method, more particularly relates to an automatic white balance adjustment method for properly adjusting a white balance according to a type of a light source.

【0002】

【Prior Art】

In a conventional white balance adjustment method, a differential signal (R − B) is calculated between

a mean value of R signals and a mean value of B signals among red (R), green (G) and blue (B) signals on the whole image. A white balance is adjusted by adjusting gains of the R signals and the B signals so that the differential signal (R − B) can approach 0. In this method, however, the white balance is not properly adjusted if the color temperature of a subject is distributed unevenly or if major parts of the image have a single color.

【0003】

In another conventional white balance adjustment method, the range for adjusting the gains of R and B signals is limited according to a luminance level of the subject so that the white balance can be principally adjusted correctly (Japanese Patent Application Publication No. 5-64219).

【0004】

【Problem to be Solved by the Invention】

For a scene in which the differential signal (R − B) cannot approach 0, however, even if the range for adjusting the gains of R signals and B signals is limited according to a luminance level, only just the incorrect adjustment is reduced but the white balance cannot be suitably adjusted by the white balance adjustment by which the differential signal (R − B) can approach 0.

【0005】

The present invention has been developed in view of the above-described circumstances and it is an object of the present invention to provide an automatic white balance adjustment method, which correctly determine the type of a light source, and adjusts the white balance suitable for the determined type of the light source.

【0006】

【Means for Solving Problem】

The above object can be accomplished by providing an automatic white balance adjustment method according to claim 1 of the present application comprising the steps of: detecting a luminance level of a subject; dividing an image plane, on which the subject is imaged, into a plurality of areas; acquiring color information of each of the areas; setting one detection frame indicating at least a color distribution range corresponding at least to a type of a light source; finding a number of the areas belonging to the detection frame in accordance with the color information of each of the acquired areas; determining a type of a light source according to the luminance level of the detected subject and the number of the areas belonging to the detection frame; and adjusting a white balance suitable for the type of the light source detected.

【0007】

The type of the light source is determined according to the luminance level of the subject and the number of the divided- image plane areas belonging to the detection frame indicating a color distribution range corresponding to the type of the light source. After determining the type of the light source, the white balance is adjusted suitably for the type of the light source. The white balance can be also adjusted suitably for the type of the light source by controlling gains of R, G, B signals to the predetected gains according to the type of the light source.

【0008】

The color information comprises a ratio R/G and B/G between R, G, B signals in areas as shown in claim 2 of the present application; and the detection frame is specified by a range of the ratio R/G and a range of the ratio B/G. The detection frame, as shown in claims 3 and 4 of the present application comprises a shade detection frame and a blue sky detection frame indicating color distribution ranges of a shade and a blue sky, respectively; and the number of the area belonging to the shade detection frame is restricted to the number of the area of which luminance is not more than a predetected luminance; and the number of the area belonging to the blue sky detection frame is restricted to the number of the area of which luminance is not less than a predetected luminance. For a scene

in which the color temperature is high, it determines whether the subject is blue due to the shade or the blue sky.

【0009】

As shown in claim 5 of the present application, the determination of the type of the light source comprises the steps of: calculating an evaluation value expressing how much the subject appears in outdoor shade according to the following equation:

the evaluation value expressing how much the subject appears in outdoor shade = F(outdoor) * F(shade) * F(blue sky),

where F(outdoor) : a value of a membership function of which variable is the luminance level and expresses how much the subject appears outdoors

F(shade) is a value of a membership function of which variable is the number of the areas wherein luminance is not more than a predetected luminance and which belong to the shade detection frame, and expresses how much the subject appears in shade

F(blue sky) : a value of a membership function of which variable is the number of the areas wherein luminance is not more than a predetected luminance and belong to the blue sky detection frame;

determining that the type of the light source is outdoor shade when the evaluation value is not less than a predetected value; and detecting that the type

of the light source is daylight when the evaluation value is not more than the predetected value. F(bleu sky) has a value operating in the direction to reduce the evaluation value expressing how much the subject appears in outdoor shade.

【0010】

As shown in claim 6 of the present application, the automatic white balance adjustment method further comprises the step of: determining whether to flash an electronic flash according to the luminance level of the detected subject, wherein the white balance adjustment in claim 5 is applied only when it is determined not to flash the electronic flash, and the white balance adjustment suitable for the electronic flash when it is determined to flash the electronic flash.

【0011】

The type of the light source, as shown in claim 7 of the present application, comprises a shade, a fluorescent lamp and an electric bulb; and the detection frames comprises a shade detection frame, a fluorescent lamp detection frame, an electric bulb detection frame, a blue sky detection frame and a skin pigmentation detection frame.

The determination of the type of the light source, as shown in claim 8 of the present application, comprises the steps of: calculating an evaluation

value expressing how much the subject appears in outdoor shade, an evaluation value expressing how much the light source appears the fluorescent lamp, and an evaluation value expressing how much the light source appears the electric bulb according to the following equations:

the evaluation value expressing how much the subject appears in outdoor shade = F(outdoor) * F(shade) * F(blue sky)

the evaluation value expressing how much the light source appears the fluorescent lamp = F_1(indoor) * F(fluorescent lamp)

the evaluation value expressing how much the light source appears the electric bulb = F_2(indoor) * F(electric bulb) * F(skin pigmentation)

where F(outdoor) : a value of a membership function of which variable is the luminance level and expresses how much the subject appears in outdoor shade

F_1(indoor) : a value of a membership function of which variable is the luminance level and expresses how much the light source is the fluorescent lamp

F_2(indoor) : a value of a membership function of which variable is the luminance level and expresses how much the light source is the electric bulb

F(shade) : a value of a membership function of

which variable is the number of the areas wherein luminance is not more than a predetected luminance and which belong to the shade detection frame, and expresses how much the subject appears as if in the shade

F(blue sky) : a value of a membership function of which variable is the number of the areas wherein luminance is not less than a predetected luminance and which belong to the blue sky detection frame;

F(fluorescent lamp) : a value of a membership function of which variable is the numbers of the areas belonging to the fluorescent lamp detection frame and expresses how much the light source appears the fluorescent lamp

F(electric bulb) : a value of a membership function of which variable is the numbers of the areas belonging to the electric bulb detection frame and expresses how much the light source appears the electric bulb

F(skin pigmentation) : a value of a membership function of which variable is the numbers of the areas belonging to the skin pigmentation detection frame and expresses how much the subject appears to include the skin pigmentation;

determining, when a maximum one of the evaluation values is not less than a predetected value, that the type of the light source is as the light source

corresponding to the maximum one of the evaluation values; and

determining that the type of the light source is daylight when it is not more than the predetected value.

【0012】

【Detailed Description of the Preferred Embodiments】

Hereunder a preferred embodiment will be described in detail for an automatic white balance adjustment method according to the present invention with reference to the accompanying drawings.

Fig. 1 is a block diagram showing an embodiment of a digital camera, to which an automatic white balance adjustment method according to the present invention is applied.

【0013】

An image of a subject is formed on a light receiving surface of a charge coupled device (CCD) 14 through a taking lens 10 and a diaphragm 12, and is converted into a signal electric charge corresponding to the quantity of incident light in each sensor. The accumulated signal electric charges are read into a shift register by read gate pulses transmitted from a CCD drive circuit 16, and are sequentially read as voltage signals corresponding to the signal electric charges by register transfer pulses. The CCD 14 has a so-called electronic shutter function for

discharging the accumulated signal electric charges by shutter gate pulses to control an electric charge accumulation time (a shutter speed).

【0014】

The voltage signals read sequentially from the CCD 14 are supplied to a correlation double sampling circuit (CDS circuit) 18, which sample-holds R, G and B signals in each pixel, and supplied to an A/D converter 20. The A/D converter 20 converts the R, G and B signals, which are fed sequentially from the CDS circuit 18, into digital R, G and B signals of 10 bits (0-1023), and then outputs the converted signals. The CCD drive circuit 16, the CDS circuit 18 and the A/D converter 20 are driven in synchronism with timing signals supplied from a timing generating circuit 22.

【0015】

The R, G and B signals outputted from the A/D converter 18 are temporarily stored in a memory 24, and then, the R,G and B signals stored in the memory 24 are supplied to a digital signal processing circuit 26. The digital signal processing circuit 26 comprises a synchronization circuit 28, a white balance adjustment circuit 30, a gamma correction circuit 32, a YC signal generating circuit and a memory 36.

【0016】

The synchronization circuit 28 converts the

dot-sequential R, G and B signals read from the memory 24 into synchronous signals, and synchronously outputs the R, G and B signals to the white balance adjustment circuit 30. The white balance adjustment circuit 30 comprises multipliers 30R, 30G and 30B for increasing or decreasing digital values of the R, G, B signals respectively. The R, G, B signals are supplied to the multipliers 30R, 30G, 30B, respectively. Gain values Rg, Gg, Bg for adjusting white balance are also supplied to the multipliers 30R, 30G, 30B, respectively, from a central processing unit (CPU) 38. The multipliers 30R, 30B, 30G multiply the above two supplies. The adjusted white balance by this multiplication, R′, G′, B′ signals are outputted to the gamma correction circuit 32. A detailed description will later be given of the gain values Rg, Gg, Bg supplied from the CPU 38 to the white balance adjustment circuit 30.

【0017】

The gamma correction circuit 32 changes the input/output characteristics to achieve desired gamma characteristics of the white-balance adjusted R′, G′, B′ signals, and changes the 10-bit signals to 8-bit signals which are outputted to the YC signal generating circuit 34. The YC signal generating circuit 34 generates a luminance signal Y and chroma signals Cr, Cb from the gamma-corrected R, G, B signals. The

luminance signal Y and the chroma signals Cr, Cb (YC signals) are stored in the memory 36.

【0018】

The YC signals stored in the memory 36 at the image-capturing are compressed in a predetected format by a compression circuit (not illustrated), and are recorded in a storage medium such as a memory card.

The CPU 38 overall controls the circuits in accordance with the inputs from the camera control part 40 including a shutter release button, etc., and performs an automatic focusing, an automatic exposure control, an automatic white balance adjustment, and the like. The auto focusing is, for example, a contrast AF for moving the taking lens 10 so that the high frequency component of the G signal achieves the maximum. When the shutter release button is half pressed, a driver 42 moves the taking lens 10 to a focusing position so that the high frequency component of the G signal achieves the maximum.

【0019】

In the automatic exposure control, a subject luminance (image-capturing EV) is found from an integrated value of R, G, B signals in one frame, and a diaphragm value and a shutter speed are detected according to the image-capturing EV. A diaphragm driver 44 drives the diaphragm 12, and the electronic shutter controls the electric charge accumulation time

to achieve the determined shutter speed. R, G, B signals in one frame are obtained again to find an image-capturing EV again. When the shutter release button is half pressed, the above-described photometry operation is repeated a plurality of times to find a correct image-capturing EV, and the diaphragm value and the shutter speed for the image-capturing are finally detected according to the image-capturing EV. When the shutter release button is fully pressed, the diaphragm driver 44 drives the diaphragm 12 in such a manner as to achieve the determined diaphragm value, and the electronic shutter controls the electric charge accumulation time in such a manner as to achieve the determined shutter speed.

【0020】

A description will now be given of the white balance adjustment method.

The digital camera has an electronic flash 46, and by operating an electronic flash key (not illustrated), has a low luminance automatic flash mode for automatically flashing the electronic flash 46 when the subject luminance is low, a compulsory flash mode for flashing the electronic flash 46 regardless of the subject luminance, a flash prohibition mode for prohibiting the electronic flash 46 from flashing, and the like. The white balance is adjusted according to the these modes.

【0021】

Referring to a flow chart of Fig. 2, there will be explained the white balance adjustment in the low luminance automatic flash mode.

If the image-capturing EV is obtained when the shutter release button is half pressed (step S10), whether to flash in low luminance or not is detected according to the image-capturing EV (step S12). If the image-capturing EV is a predetected value (10EV) or less, it is determined to flash in low luminance, and the white balance is adjusted suitable for the electronic flash light (step S14). More specifically, the white balance gain values Rg, Gg, Bg are previously prepared to satisfactorily adjust the white balance according to the electronic flash light, and the gain values Rg, Gg, Bg are supplied to the white balance adjustment circuit 30.

【0022】

If it is determined not to flash in low luminance, the entire image plane is divided into a plurality of areas (64×64), and average integrated values of R, G, B signals in the respective areas are found to thereby find a ratio R/G between the integrated value of the R signal and the integrated value of the G signal and a ratio B/G between the integrated value of the B signal and the integrated value of the G signal (step S16). An integration circuit 48 in Fig. 1 calculates the

average integrated values of the R, G, B signals in each area, and the average integrated values are supplied to the CPU 38. Multipliers 50R, 50G, 50B are provided between the integration circuit 48 and the CPU 38, and adjustment gain values are supplied to the multipliers 50R, 50G, 50B to adjust the unevenness between the multipliers 50R, 50G, 50B.

【0023】

Next, how much the subject appears in outdoor shade or not is detected (step S18). The detection how much the subject appears in outdoor shade is based on the calculation an evaluation value how much the subject appears in outdoor shade as follows:

【0024】

【Equation 1】

Evaluation value expressing how much the subject appears both outdoors and in shade = F(outdoor) * F(shade) * F(blue sky)

where F(outdoor) is ,as shown in Fig. 5, a value of a membership function of which variable is the image-capturing EV value, and expresses how much the subject appears outdoors, F(shade) is, as shown in Fig. 7, a value of a membership function shown of which variable is the number of areas where in luminance is not more than a predetected luminance and within a shade detection frame and expresses how much the subject appears in shade, and F(blue sky) is, as shown

in Fig. 8, a value of a membership function of which variable is the number of areas wherein luminance is not less than a predetected luminance and within a blue sky detection frame and expresses how much the scene appears to include a blue sky.

【0025】

The luminance (Evi as EV value) in each area is calculated by the following equation:

【0026】

【Equation 2】

$$Evi = Ev + \log_2 (Gi / 45),$$

where Ev : the image-capturing EV value

Gi : an average integrated value of G in each area

In this equation, 45 is an optimum value among the converted A/D values.

【0027】

As shown in Fig. 4, the shade detection frame, the blue sky detection frame, and the like are shown in a graph of which horizontal axis is ratio R/G and vertical axis is ratio B/G, and each detection frame specifies a color distribution of a type of a light source or the like.

F(shade) is found from the membership function in Fig. 7 on the basis of the number of areas that have Evi as Evi value of 12 or less, which is calculated by the [equation 2] and also have both ratios R/G and

B/G belonging to the shade detection frame in Fig. 4. Likewise, F(blue sky) is found from the membership function in Fig. 8 on the basis of the number of areas that have Evi as EV value of more than 12.5 and also have both ratios R/G and B/G belonging to the blue sky detection frame in Fig. 4. F(blue sky) has a value operating so as to decrease the evaluation value expressing how much the subject appears both outdoors and in shade as the number of areas within the blue sky detection frame increases.

[0028]

At the step S18 in Fig. 2, the values of the membership function of F(outdoor), F(shade) and F(blue sky) are integrated to find the evaluation value expressing how much the subject appears both outdoors and in shade. At the step S20, it is determined whether or not the evaluation value found at the step S18 is a predetected reference value (0.47 in this embodiment) or more. If the evaluation value is 0.47 or more, it is determined that the subject is both outdoors and in shade and the white balance is adjusted suitably for the outdoor shade (step S22).

[0029]

If the evaluation value is less than 0.47, it is determined to be daylight (fair weather), and the white balance is adjusted suitably for the daylight (step S24). Regarding to the white balance adjustment

suitable for the outdoor shade or daylight, the white balance gain values Rg, Gg, Bg are prepared in advance in order to satisfactorily adjust the white balance for the outdoor shade and the daylight and supplying by the suitable gain values Rg, Gg, Bg to the white balance adjustment circuit 30.

【0030】

Referring next to a flow chart in Fig. 3, there will be explained the white balance adjustment method in the flash prohibition mode.

In this case, the image-capturing EV is acquired when the shutter button is half pressed (step S30), and likewise in step S16 of Fig.2, the R/G and B/G are found in 64×64 areas divided from the entire image plane (step S32).

【0031】

Next, evaluation values expressing how much the light source appears a fluorescent lamp (a daylight, a white daylight, a white light) or a tungsten electric bulb as well as the evaluation value expressing how much the subject appears both outdoors and in shade are calculated by the following equations.

【0032】

【Equation 3】

Evaluation value expressing how much the light source appears a daylight = F_1(indoor) * F(daylight fluorescent lamp)

【0033】

【Equation 4】

Evaluation value expressing how much the light source appears a white daylight = F_1(indoor) * F(white daylight light fluorescent lamp)

【0034】

【Equation 5】

Evaluation value expressing how much the light source appears a white = F_1(indoor) * F(white fluorescent lamp)

【0035】

【Equation 6】

Evaluation value expressing how much the light source appears a tungsten electric bulb = F_2(indoor) * F(electric bulb) * F(skin pigmentation)

In the above [Equations 3] to [Equations 5], as shown in Fig 6, F_1(indoor) is a value of a membership function of which variable is the image-capturing EV value and expresses how much the subject appears indoors (the fluorescent lamp). F_2(indoor) as shown in Fig.6 , is a value of a membership function shown in Fig. 6 of which variable is the image-capturing EV value (value in parentheses) and expresses how much the subject appears indoors (the tungsten electric bulb).

【0036】

In the above [Equations 3]to[Equations 6], F(daylight fluorescent lamp), F(white daylight fluorescent lamp), F(white fluorescent lamp) and F(electric bulb) are values of membership functions shown in Fig. 9 of which variables are the numbers of areas within a daylight detection frame, a white daylight detection frame, a white detection frame and a tungsten electric bulb detection frame, respectively, in Fig. 4 ,and express how much the light source appears the fluorescent lamp · the tungsten electric bulb, respectively.

【0037】

In the above [Equation 6], F(skin pigmentation) is a value of a membership function shown in Fig. 10 of which variable is the number of areas belonging to a skin pigmentation detection frame in Fig. 4 and expresses how much the subject appears to include a skin pigmentation. F(skin pigmentation) operates in such a manner as to lower the evaluation value expressing how much the light source appears the electric bulb as the number of areas within the skin pigmentation detection frame increases. This is because a red tinge disappears and a white tinge appears resulting in a pale complexion if the white balance is adjusted intensively with respect to the tungsten electric bulb for the scene that the subject including the skin pigmentation.

【0038】

When the evaluation value how much the subject appears both outdoors and in shade (see the [Equation 1]), the evaluation value how much the light source appears the daylight, the evaluation value how much the light source appears the white daylight, the evaluation value how much the light source appears the white and the evaluation value how much the light source appears the electric bulb are calculated, it is detected whether or not the value of the maximum one of these five evaluation values is 0.47 or more (step S36 in Fig. 3). If the maximum value is 0.47 or more, the white balance is adjusted according to the color of the light source corresponding to the maximum evaluation value (step S38).

【0039】

If the maximum evaluation value is less than 0.47, it is determined to be the daylight, and the white balance is adjusted suitably for the daylight (step S40).

In order to satisfactorily adjust the white balance suitably for the outdoor shade, the daylight fluorescent lamp, the white daylight fluorescent lamp, the white fluorescent lamp, the tungsten electric bulb and the daylight, the white balance gain values Rg, Gg, Bg are previously prepared, and the suitable gain values Rg, Gg, Bg are supplied to the white balance

adjustment circuit 30.

【0040】

More specifically, when Rg, Gg, Bg are the preset gain values and R, G, B are the signals to be corrected, the white balance adjustment circuit 30 obtains the corrected signals R′, G′, B′ as follows.

【0041】

【Equation 7】

$$R' = Rg \times R$$

$$G' = Gg \times G$$

$$B' = Bg \times B$$

【0042】

The gain values may be changed according to the degree of the scene (the evaluation value) as shown in the following equations.

【0043】

【Equation 8】

$$R' = \{(Rg - 1) \times (\text{evaluation value}) + 1\} \times R$$

$$G' = \{(Gg - 1) \times (\text{evaluation value}) + 1\} \times G$$

$$B' = \{(Bg - 1) \times (\text{evaluation value}) + 1\} \times B$$

The preset gain values Rg, Gg, Bg for the different types of light sources are empirically set within the range between 0.9 and 1.5. If the gain values are changed according to the evaluation value, the continuity of the scenes is maintained.

【0044】

In this embodiment, the evaluation values for detecting the type of the light source are calculated by the [Equation 1], [Equation 3] to [Equation 6], but the evaluation values may also be calculated by taking one or more other factors (other membership functions) into account. The types of the light sources should not be restricted to this embodiment; for example, only one or two kinds of fluorescent lamps may be detected.

【0045】

【Effect of the Invention】

As set forth hereinabove, according to the present invention, the type of the light source is determined correctly, so that the white balance can be satisfactorily adjusted suitably for the type of the light source.

【Brief Description of the Drawings】

【Fig. 1】

a block diagram showing an embodiment of a digital camera, to which an automatic white balance adjustment method according to the present invention is applied

【Fig. 2】

a flow chart for explaining an automatic white balance adjustment method in a low luminance flash mode

【Fig. 3】

a flow chart for explaining an automatic white balance adjustment method in a flash prohibition mode

【Fig. 4】

a graph showing detection frames indicating the color distribution ranges of various light sources

【Fig. 5】

a graph showing a membership function expressing how much the subject appears outdoors

【Fig. 6】

a graph showing a membership function expressing how much the subject appears indoors

【Fig. 7】

a graph showing a membership function expressing how much the subject appears in outdoor shade

【Fig. 8】

a graph showing a membership function expressing how much the scene appears to include a blue sky

【Fig. 9】

a graph showing a membership function expressing how much the light source appears a fluorescent light or an electric bulb

【Fig. 10】

a graph showing a membership function of a skin pigmentation

【Brief Description of the Reference Numbers】

10…taking lens

12…diaphragm

14…charge coupled device (CCD)

30…white balance adjustment circuit

30R, 30G, 30B…multiplier

38…central processing unit (CPU)

46…electronic flash

48…integration circuit

[Document Name] Figure
[Fig.1]

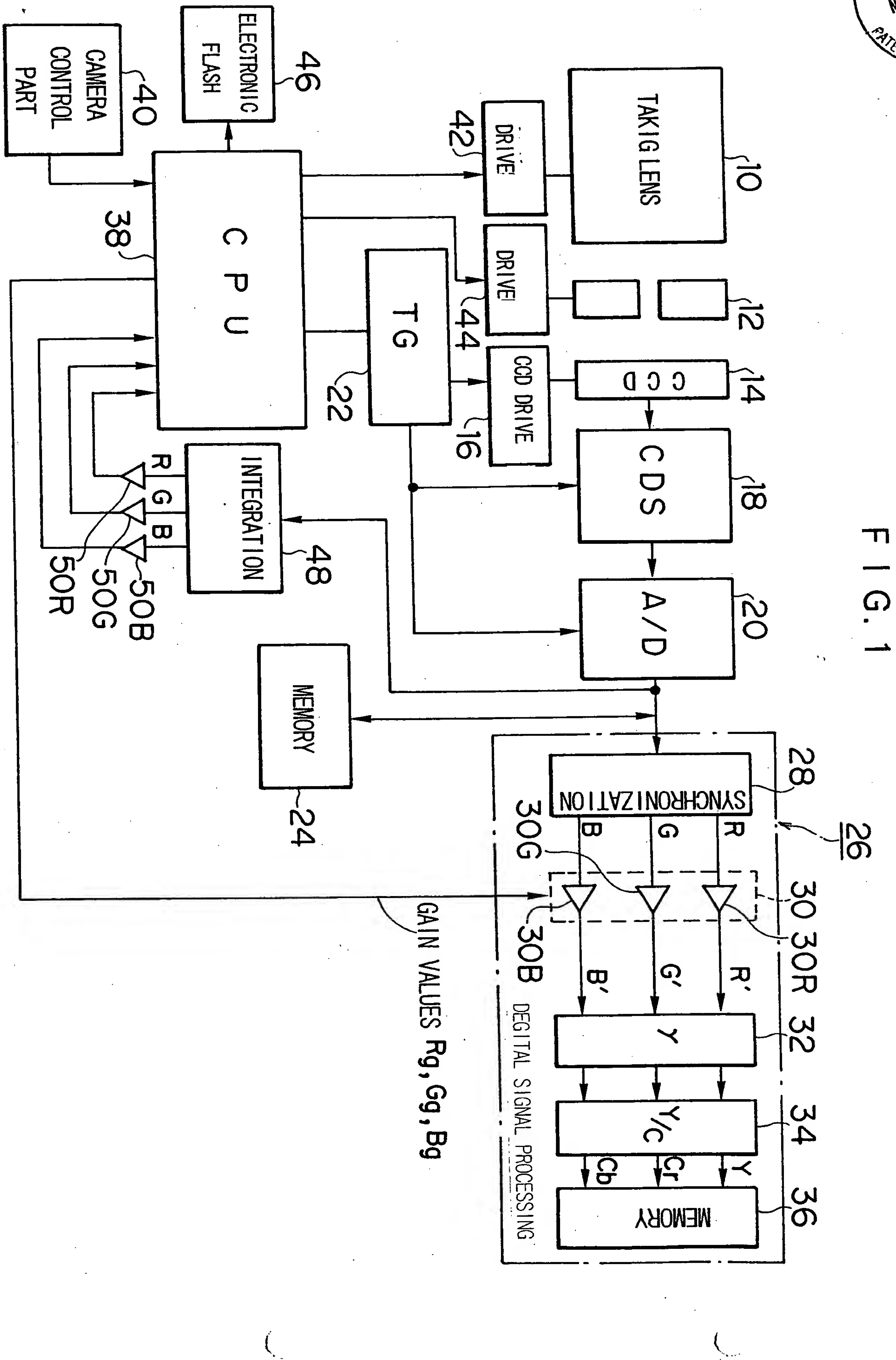
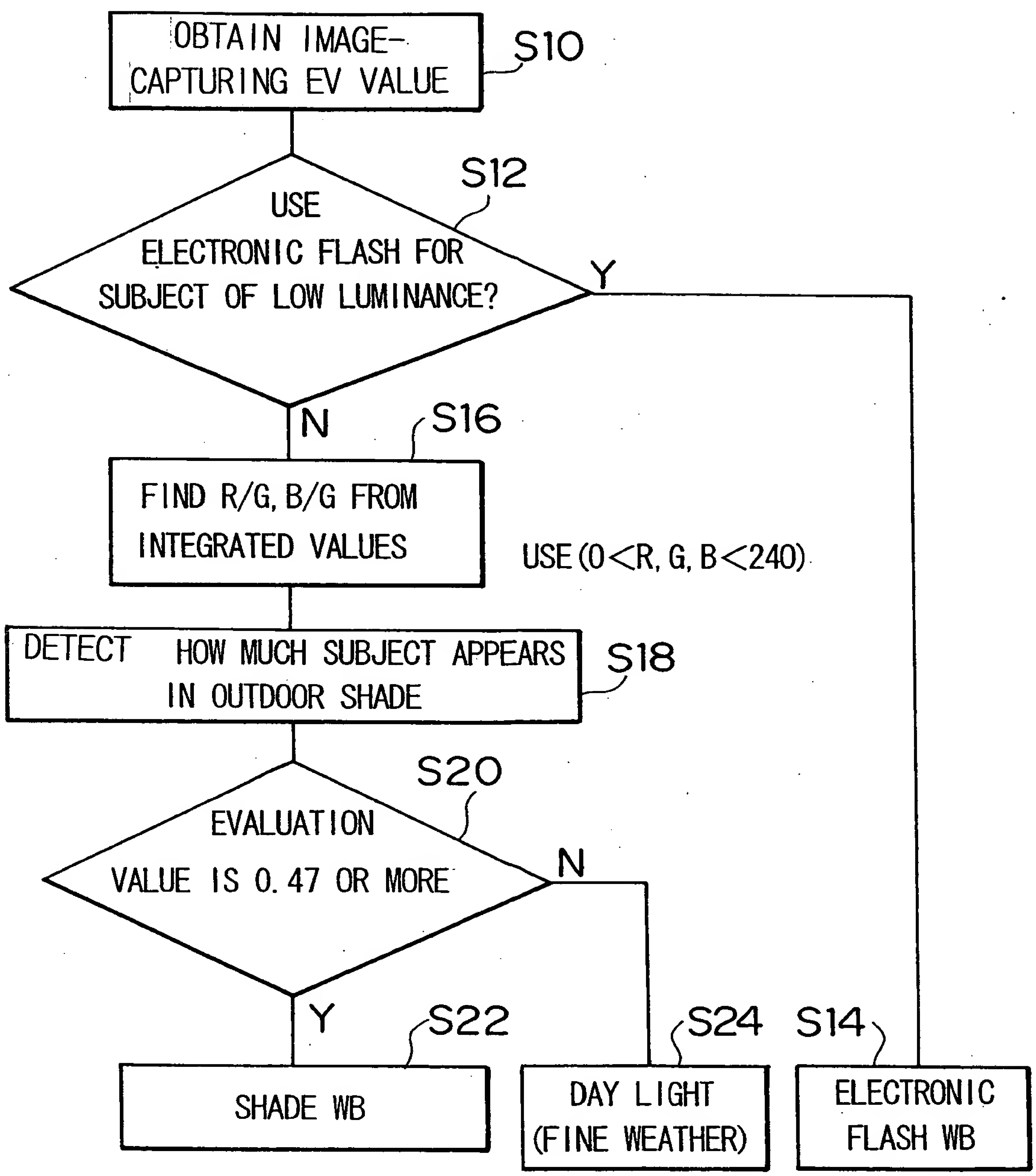


FIG. 1

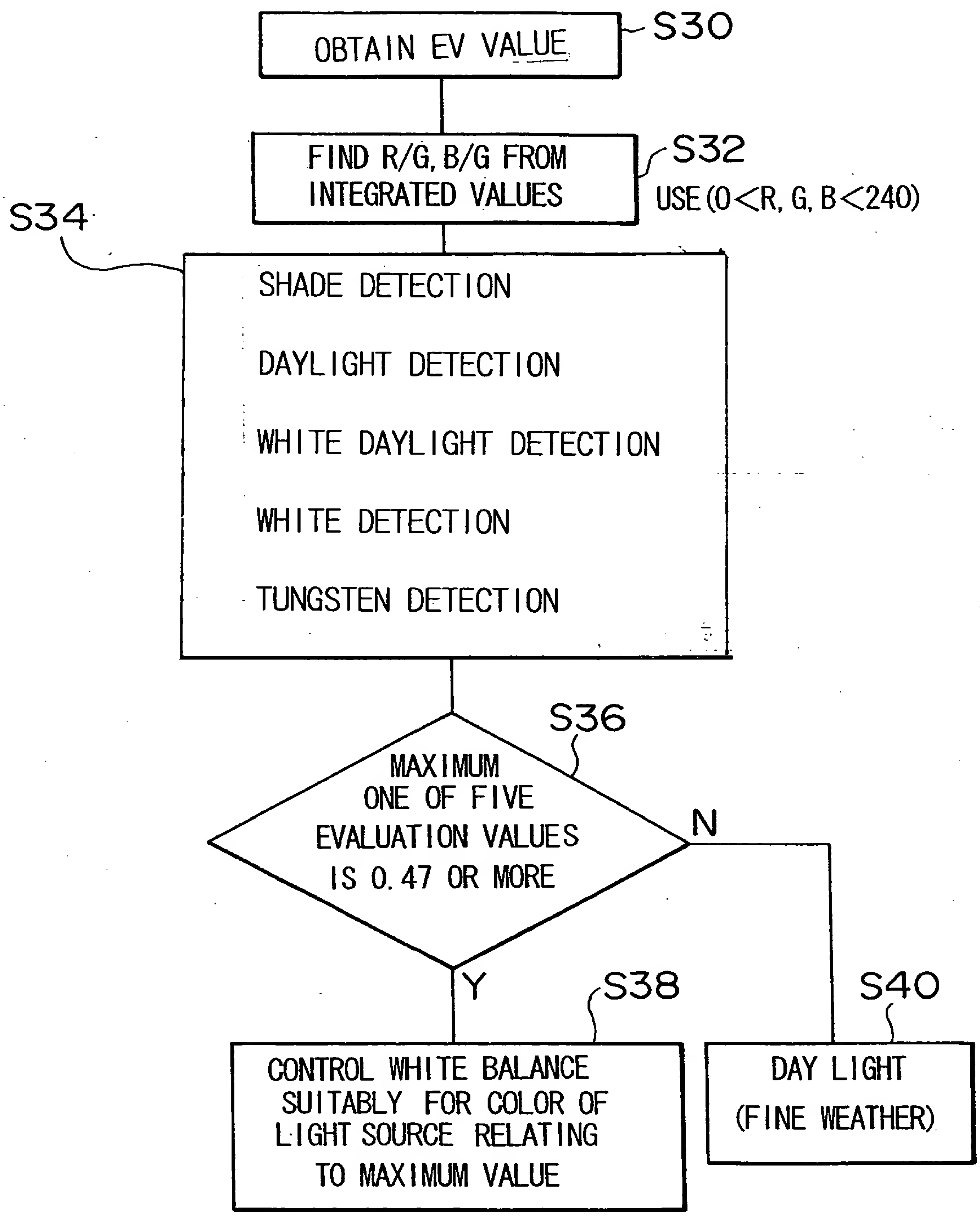
[Fig.2]

F I G. 2


OBTAIN IMAGE-CAPTURING EV VALUE
S10
USE ELECTRONIC FLASH FOR SUBJECT OF LOW LUMINANCE?
S12
Y
N
S16
FIND R/G, B/G FROM INTEGRATED VALUES
USE (0<R, G, B<240)
DETECT HOW MUCH SUBJECT APPEARS IN OUTDOOR SHADE
S18
S20
EVALUATION VALUE IS 0.47 OR MORE
N
Y
S22
S24
S14
SHADE WB
DAY LIGHT (FINE WEATHER)
ELECTRONIC FLASH WB

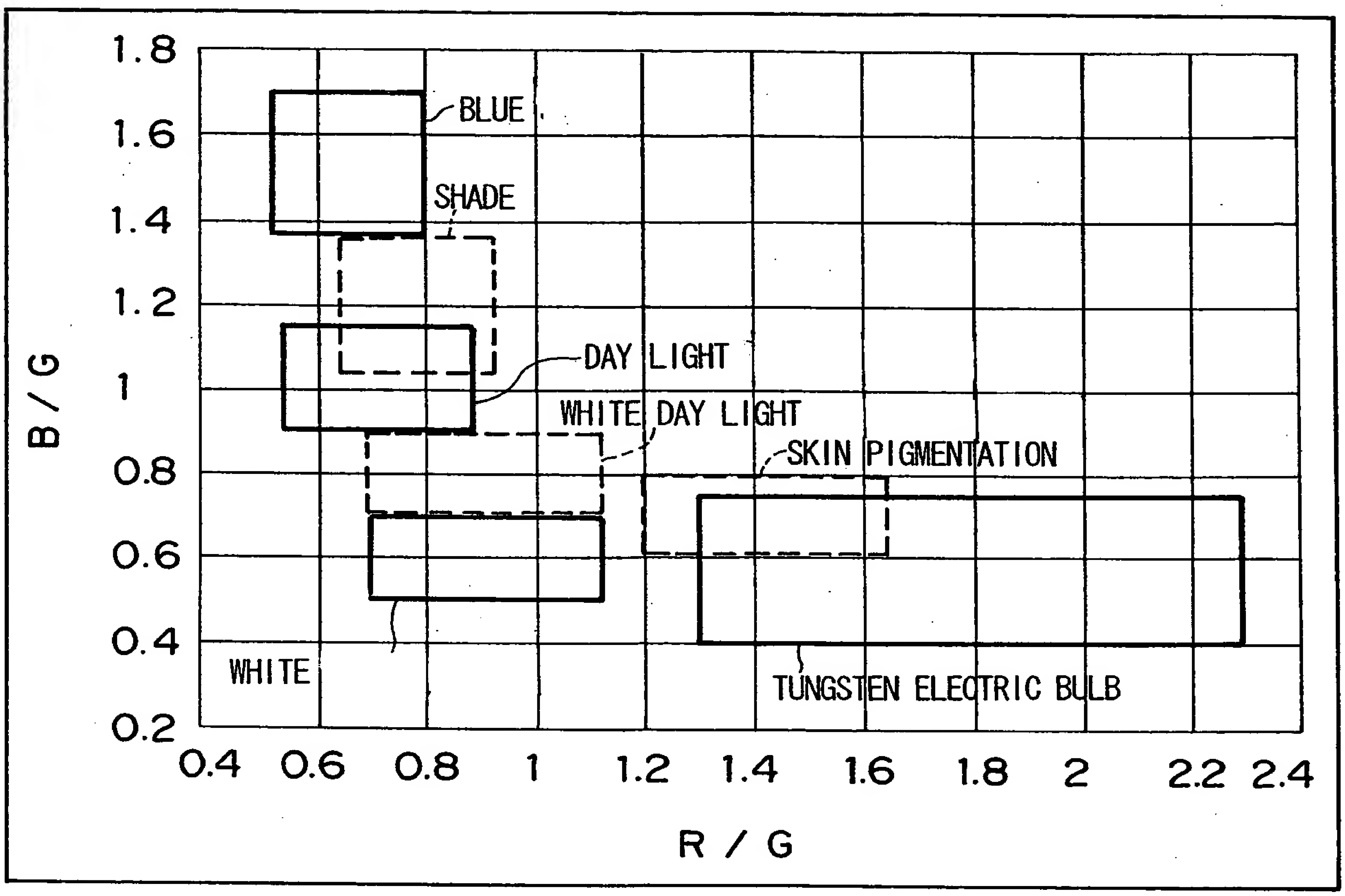
[Fig.3]

F I G. 3


OBTAIN EV VALUE
S30
FIND R/G, B/G FROM INTEGRATED VALUES
S32
USE (0<R, G, B<240)
S34
SHADE DETECTION
DAYLIGHT DETECTION
WHITE DAYLIGHT DETECTION
WHITE DETECTION
TUNGSTEN DETECTION
S36
MAXIMUM ONE OF FIVE EVALUATION VALUES IS 0.47 OR MORE
N
Y
S38
S40
CONTROL WHITE BALANCE SUITABLY FOR COLOR OF LIGHT SOURCE RELATING TO MAXIMUM VALUE
DAY LIGHT (FINE WEATHER)

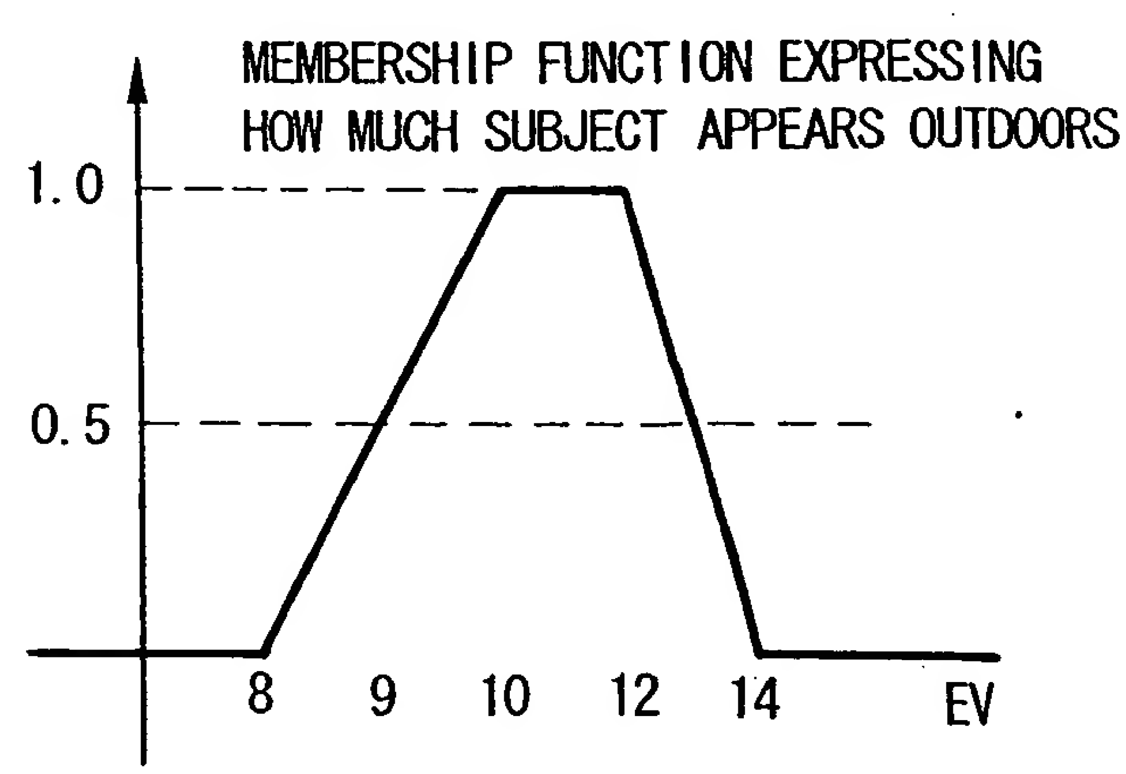
[Fig.4]

F I G. 4



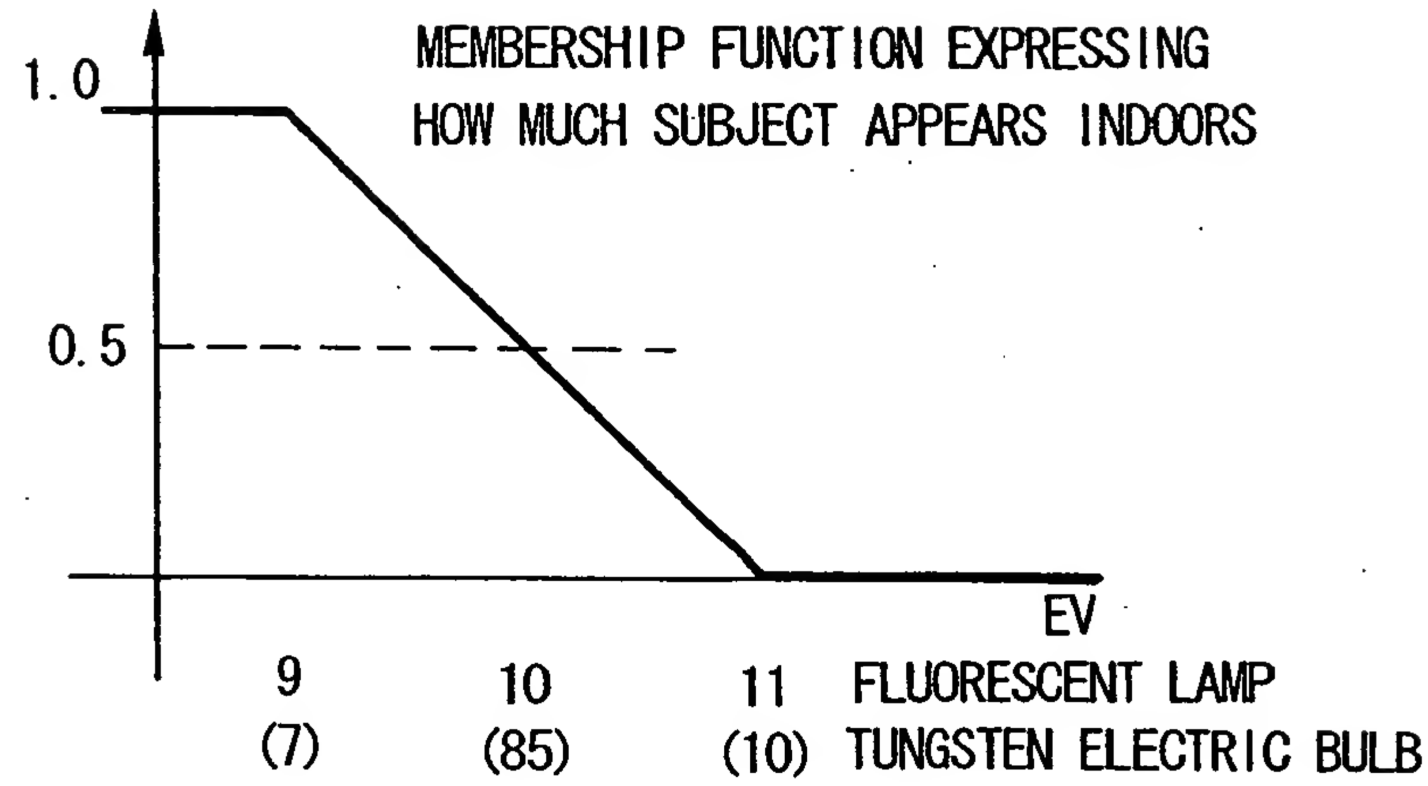
[Fig.5]

F I G. 5



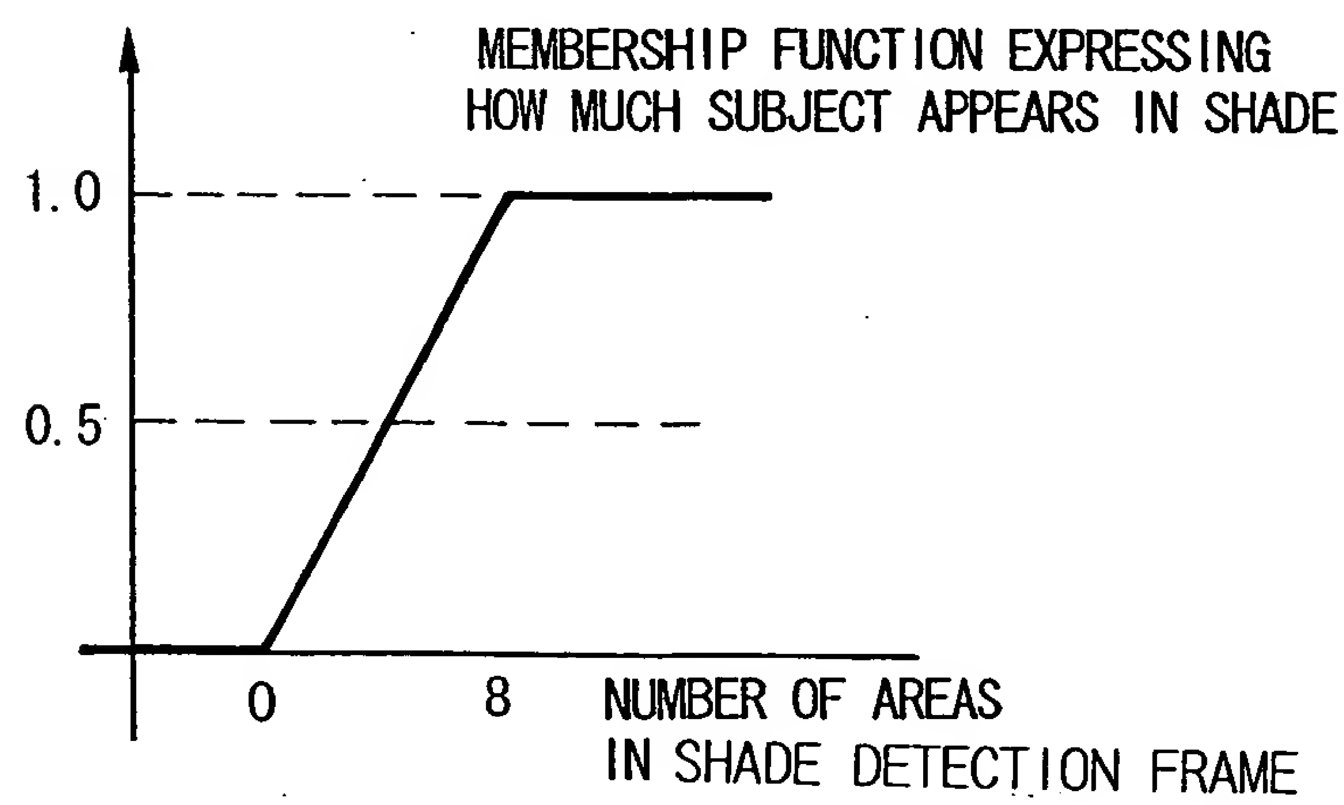
[Fig.6]

F I G. 6



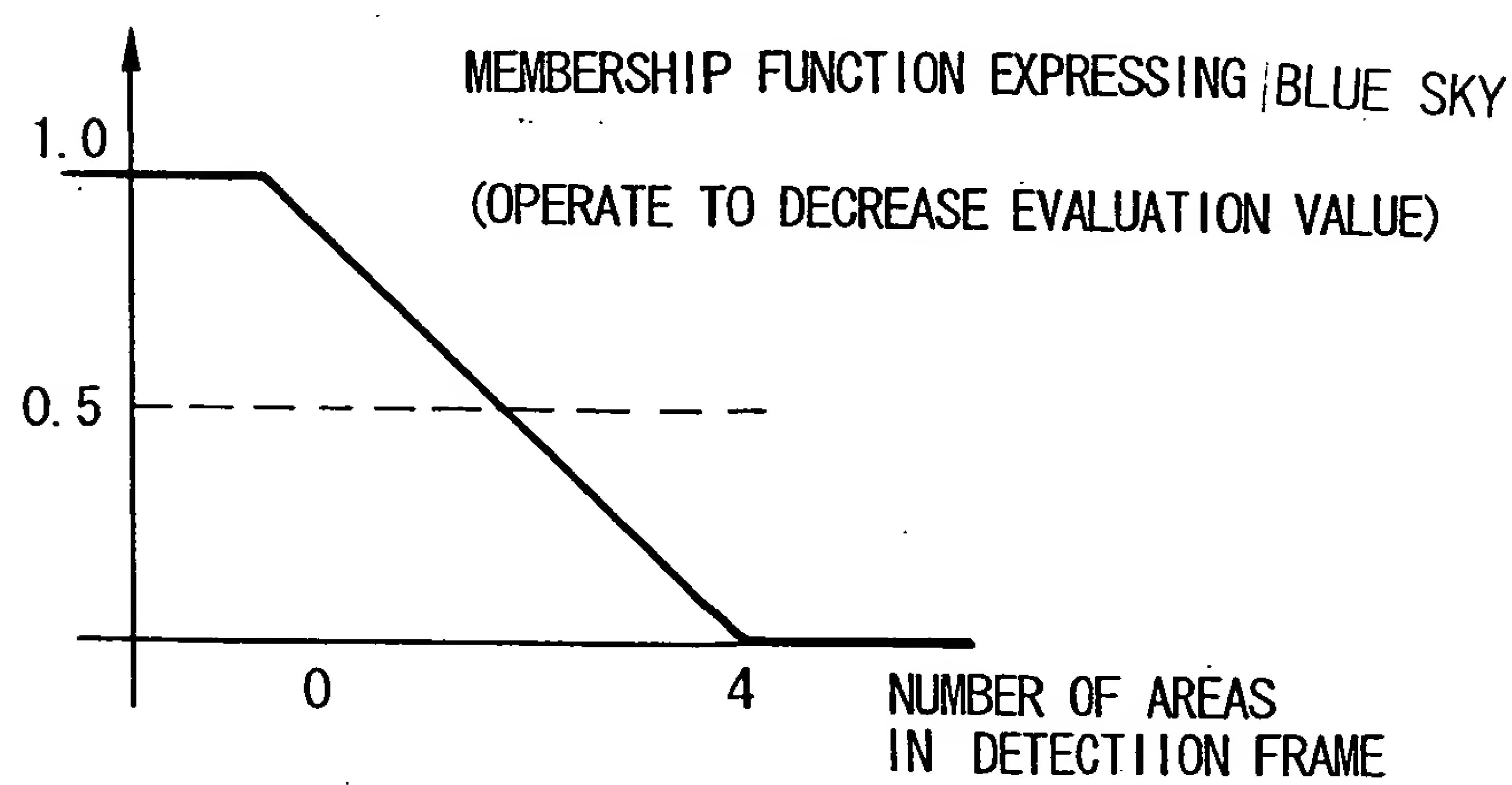
[Fig.7]

F I G. 7



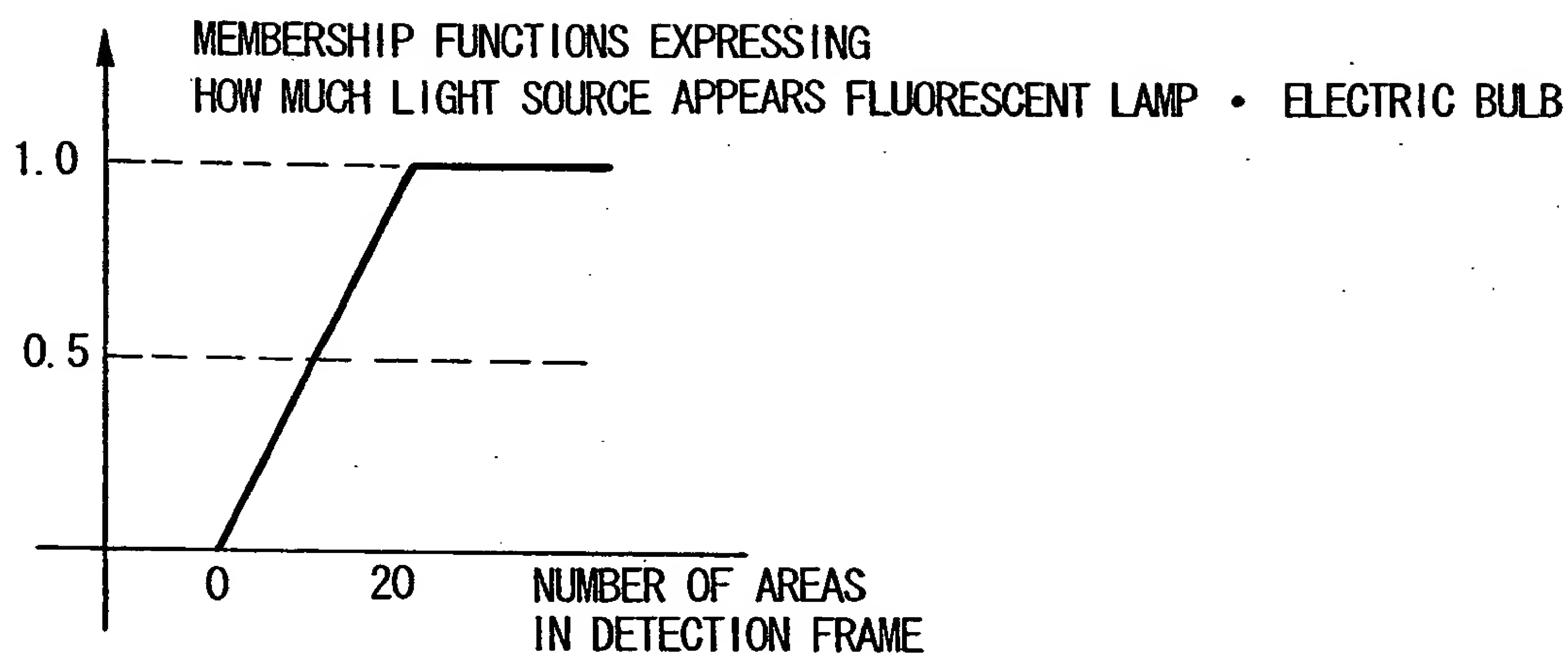
[Fig.8]

F I G. 8



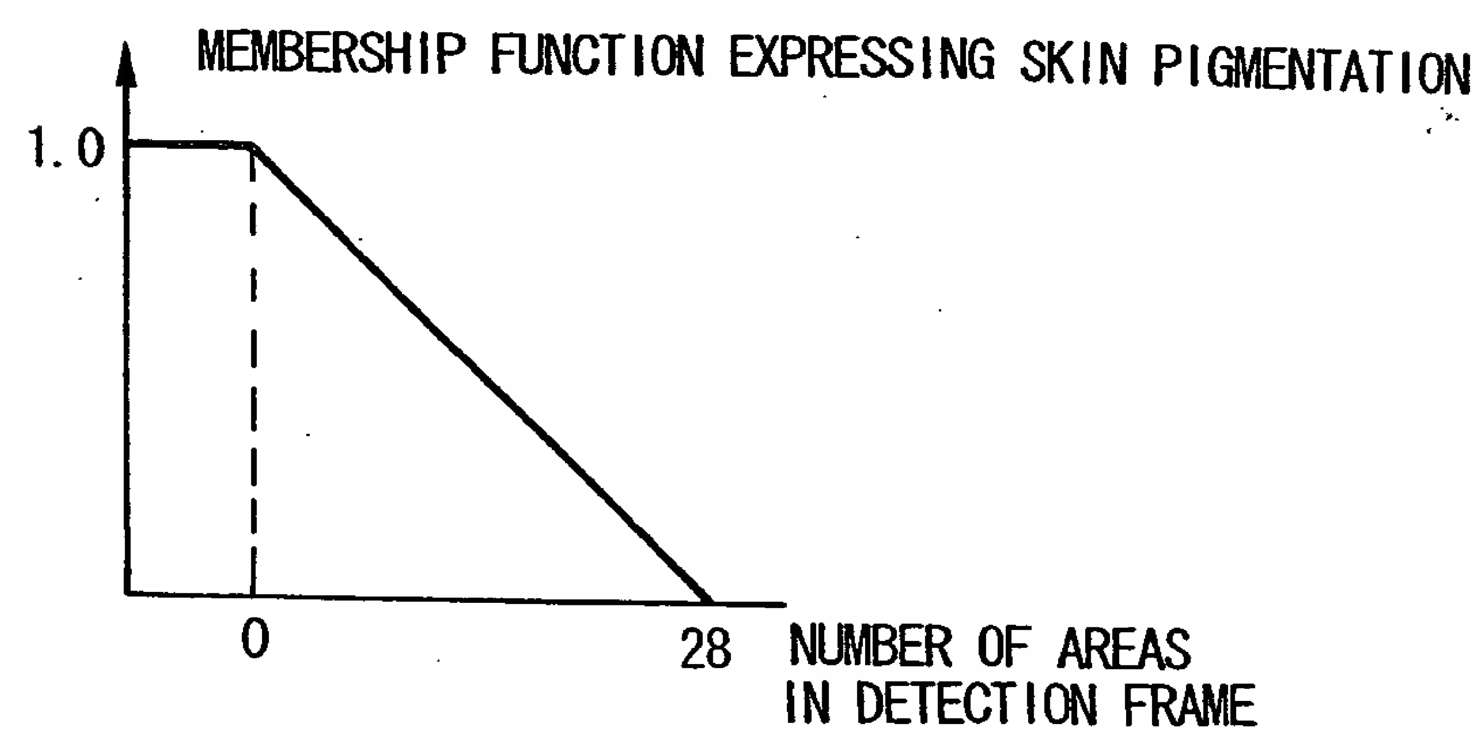
[Fig.9]

F I G. 9



[Fig.10]

F I G. 1 0



【Document Name】 Abstract

【Abstract】

【Assignment】 It makes possible to correctly determine the type of a light source and adjust the white balance suitable for the determined type of the light source.

【Means for Solution】 An image-capturing EV value is obtained when a shutter release button is half pressed(step S10), and whether to flash an electronic flash for a subject of low luminance is determined according to the image-capturing EV value (step S12). If it is detected that the electronic flash should be flashed for the subject of low luminance, a white balance is adjusted suitably for an electronic flash light (step 14). If it is determined that the electronic flash should not be flashed for the subject of low luminance, color information relating to a plurality of areas divided from an image plane is acquired, and the number of areas belonging to a shade detection frame (a frame which indicates a color distribution range corresponding to the shade) is found according to the acquired color information of each areas. Then, whether a type of the light source is the shade or the daylight is determined according to the obtained image-capturing EV value and the number of areas belonging to the shade detection frame (step S20). The white balance is adjusted suitably for the determined type of the light source (step S22, step

S24).

【Selected Drawing】 Fig. 2